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ANATOMY AND PHYSIOLOGY OF THE FAMILY NEPIDÆ.[1]

BY WILLIAM A. LOCY.

THE value arising from a study of the organs and their functions in any animal, is not limited to a knowledge of the form studied nor to the facts obtained. The general principles of comparative anatomy and physiology will be thus developed, since they exist in the study of the bodies of all animals, and furthermore, the study of a typical form will furnish a key to a more special knowledge of a whole group, just as a type language affords a key to a group of languages. In studying the anatomy and physiology of the family Nepidæ, then, results are obtained which reach far beyond the boundaries of the family, and which constitute simply special cases to illustrate the principles of comparative anatomy and physiology.

The functions performed by the organs of animals' bodies naturally fall into three groups, nutrition, reproduction and relation, which will form special divisions of this subject to be treated after considering a few generalities.

Methods of work, etc.—The more general methods are briefly considered here, the special methods, when requiring mention, are spoken of in connection with the work for which they are designed.

To dissect successfully the Insecta, it is necessary to work under water or some other transparent liquid, therefore a dissecting slab and a tray are essential. The former is easily made by loading cork or soft wood until it will sink under water; it is better to paint this black to furnish a good background, since the tissues of insects are usually white. Any vessel of convenient size will serve as a tray.

In opening the specimen, which may be done along the median line or at the side, care should be taken to cut simply the integument, which, before cutting, should be raised with the forceps and carefully freed from all attachments. The insect is then to be pinned out upon the slab and dissected under water or alcohol.

The working outfit necessary is neither costly nor extensive, the apparatus just described and the following will be found adequate for all ordinary work: (1) A pair of fine scissors with curved points; (2) a fine scalpel for general cutting; (3) needles mounted in wooden handles are very convenient for separating the tissues and removing small portions piecemeal, these ground to an edge and sharpened form very fine cutting instruments; (4) fine pliers or forceps; (5) a good pocket lens, or better, a dissecting microscope. For all histological work and fine anatomy, a good compound microscope which, however, need not cost more than $35 or $50, is necessary.

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[1] Thesis to obtain the Degree of Master of Science, submitted to the University of Michigan.

Habits, etc.—The family Nepidæ, of the Hemiptera, is represented in our waters by four distinct genera, Belostoma, Perthostoma, Nepa and Ranatra. They are of common occurrence in the ponds and streams about Ann Arbor, except Nepa, which is rarely found. The first three mentioned are flattened and oval in outline, while Ranatra is remarkable for its long linear form.

Belostoma and Perthostoma, the most active forms, have their hind legs admirably fitted for swimming. Ranatra and Nepa, to correspond with their habits, have their hind legs fitted for crawling along the bottom and upon aquatic plants. The fore legs of all the genera are raptorial and armed with a terminal claw. In Ranatra this fits into a groove in the tibia, as the blade of a knife fits into the handle. In the other genera the femur is grooved to receive the fore leg, and the trochanter, the terminal claw. The prey is seized by these raptorial legs and conveyed to the mouth; it is here punctured by the three-jointed beak and the nutriment sucked out. Their food consists of the juices of larval insects, tadpoles, young fish, gasteropods, etc. In Ranatra and Nepa the antennæ are three-jointed, in Belostoma and Perthostoma four-jointed, and concealed in a vaulted cavity opening below the eyes.

The adult Belostomæ are very large, ranging from three to four and a half inches in length, and are the brigands of the streams they inhabit. From their rapacious habits they soon exhaust the food from one locality, then fly to another during the night. They attack aquatic forms several times their own size. In an aquarium I remember having once seen a large Belostoma kill a frog four times its size, despite the fierce struggles of the frog to escape.

In general appearance Ranatra resemble the "walking-sticks." The body ends posteriorly in two long setæ, the grooved faces of which, applied together, form a respiratory tube as long as the abdomen. The front legs are very long, and extend straight out in front of the body, which throws the center of gravity too far forward for convenient flight.

When preparing for flight the air sacs are first inflated, the prothorax and head are thrown downward, and the front legs disposed of in a very ingenious manner. The femurs are bent upon the joint near the head, a little more than 90° from their original position, and the tibiæ are folded closely against these, thus the front legs hang under the body, directed a little backward.

Though of much smaller size, Perthostoma strongly resembles Belostoma in general appearance, but is quite distinct in antennæ, beak and legs. The females of the genus carry their eggs on the back, regularly arranged in a single layer, cemented to the body by a substance insoluble in water. The eggs of the other genera are attached to the water plants and submerged objects.

Belostoma, Perthostoma and Ranatra are infested by a Hydrachna, which is found attached to different parts of the body. This is probably also true of Nepa, but I have not had the specimens to determine. For a fuller account of the external anatomy and the family characteristics, the reader is referred to the works on systematic entomology, while attention is now called to the *internal anatomy.*

A. The Function of Nutrition.

The function of nutrition includes all the processes concerned in preserving the organism of an animal, as the digestion of food, its conveyance to a point for use, the chemical changes of converting food into tissue, and the removal of waste matter. These processes are carried on by the organs of digestion, of circulation, of respiration and of excretion, which form separate subheads for consideration.

I. The Digestive System.

On opening the insect the most prominent set of organs is the alimentary canal and its appendages. The thread-like œsophagus, characteristic of suctorial insects, extends straight from the beak to the metathorax, where it enlarges abruptly into the stomach. The anterior end of the œsophagus is connected with a peculiar pumping apparatus, which will be described later. The division of the digestive apparatus into a distinct crop, chylific ventricle, etc., frequently found among insects, is practically obliterated in these insects; this, indeed, is the case in most of the Hemiptera Sometimes in Ranatra an oval enlargement exists at the beginning of the stomach (Fig. 3) and another at the end not so well marked, but in neither case are they distinctly separate from the rest of the stomach.

The stomach, taken as a whole, is of unusual size, and much saculated by contraction. In the third abdominal segment its pyloric end opens into the intestine. Both stomach and intestine consist of at least two coats, an external muscular coat and an internal mucous coat. The existence of a third coat in the Hemiptera is a disputed point; though Dr. Leidy mentions it in Belostoma, and I have found it, to the best of my belief, in Ranatra.

The muscular coat consists of both longitudinal and annular fibers, the former predominating. The peristaltic contractions of the alimentary canal are due to these muscular layers, and in the insects under consideration these movements are very energetic and thorough, separating the liquid food into chyle and excrementa. The mucous layer extends the entire length of the alimentary canal, and is most easily observed at the pharynx and at the anus.

Before emptying into the cæcum, the intestine is divided into an anterior and posterior portion by a bulbous enlargement, upon which the Malpighian tubules are situated. The first part may be conveniently called the duodenum, as some authors call it, and the after part the ilium. The duodenum is convoluted upon itself several times. In Belostoma it turns from its origin, first to the left, then upward, running along the left side of the stomach to about one-third its length, then turning upon itself, returns to the median line of the body; from this point it passes upward on the right side of the stomach, turns with an irregular loop and reaches again the median line, where it enlarges into the bulb. The tissues of the duodenum are the same as those of the stomach.

The ilium is slightly larger than the duodenum and coils upon itself five or six times in a sigmoid manner. In the greater number of specimens dissected, the coils were six in number. The ilium empties into a cylinder larger than itself, which represents the colon or rectum. The upper portion, which is separated from the lower by a slight constriction, is sometimes considered as representing the colon, and the lower portion the rectum. This latter diminishes rapidly, and ends in a pointed opening at the anal aperture, which is situated above and behind the genital orifice.

From the colon a large cæcal pouch extends forward, beneath the intestine, reaching in its ordinary condition to the middle of the fourth ventral segment. This is the cæcum. It is sometimes so distended with air as to reach even to the thorax, and to give a bloated appearance to the usually flattened ventral surface of the insect. This organ probably plays the same part as the air bladder of some fishes, serving as a natatory vesicle. I have often seen these insects come to the surface and forcibly expel the air from the cæcum. When the abdomen is just below the surface, the water is thrown upward in jets by the discharged air. I have also noticed the larvæ of Belostoma, when irritated, throw from the anus jet after jet of a strong smelling, light-greenish fluid, the propulsive force of which probably comes from the cæcum.

Frequently when the insects have died in water, the cæcum, naturally white, is found swelled and of a dark-blue or livid color. From the large number of cases in which this has been observed, I think that it is due to some disease. The chief differences in the alimentary canal of Belostoma and Ranatra may be seen by comparing Figs. 3 and 5.

Method of taking Food.—In order to understand how these insects take their food, we must first study the food-taking organ, or the beak. This is a three-jointed tubular structure formed from the modified mouth parts. All masticatory characters are obliterated, the labium is elongated and folded upon itself, forming a sort of trough, which is nearly closed at the top; within this the maxillæ and mandibles are found modified into four bristles which, before entering the trough, pass through a sheath made from the labrum. This sheath projects into the beak, or trough, from above (Fig. 2).

By the action of these bristles the prey is punctured and the food-juices brought to the real sucking organ, the "pharynx." This is a stiff chitinous trough, roofed by a plate of chitine, into which the œsophagus enters from behind. The sides of this trough extend much above the roofing, as shown in a cross section of the apparatus (Fig. 7); from the elevated middle of the roof chitinous threads originate, to which muscles are attached. These extend upward, first in one sheet, then divide into two parts, one going to the left the other to the right, and are attached to the integument of the head. There is no other apparent sucking apparatus in the body, and the only use I can assign to the structure just described, is that of a *pumping organ.* It is probable that the liquid food is sucked into the pharynx by the contraction of the muscles which are attached to the chitinous threads; this process enlarges the pharynx cavity by lifting the roof. From the pharynx the food passes, by muscular contraction, down the œsophagus. [Plates to follow with succeeding number.]

(To be continued.)

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THE CREODONTA.

BY E. D. COPE.

PRESENT knowledge justifies the generalization that, since the Eocene period, the mammalian fauna of the Northern hemisphere has diminished in the number of its species and genera. The Eocene fauna was richer than the Miocene; the Miocene than the Pliocene, and the Pliocene was richer than the modern fauna. With this numerical diminution in species has come increased specialization of structure, which means both greater perfection of mechanism and greater diversity of type.[1]

The order of Carnivora is a universal and well-known factor of the mammalian life of the present period. It was equally so in the Pliocene and Miocene periods. When we come to examine the overflowing life of undoubted Eocene time, we can no longer find mammals which possess the essential characters of the order. The Carnivora are unguiculate gyrencephalous mammalia with a coössified scaphoid and lunar bone of the carpus, called, therefore, the scapholunar bone. They have a grooved astragalus. No scapholunar bone has yet been found in any Eocene mammal in North America, and it is doubtful whether any has been found in Europe. Nevertheless the Eocene fauna did not lack predatory flesh-eaters whose function was like that of the Carnivora of later periods, to restrain the undue increase of all other forms of life. Their variety was greater than that presented by their carnivorous successors on the North American continent, and their numbers were proportioned to the general luxuriance of the life which furnished them subsistence. There were species whose size and powers of destruction equaled those of the bears, lions and tigers of modern times. Species of medium size abounded,

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[1] This generalization was published in the Report U. S. G. G. Survey W. of 100th meridian, 1877, IV, p. 385.